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Review Article

Augmented Reality Innovation in Prosthodontics and Smile Design

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Abstract

Prosthetic dentistry is one of the dental branches that has evolved remarkably, taking advantage of the latest digital innovations. Augmented reality (AR) is one of the digital technology advances that superimpose virtual and real objects in the surrounding environment. AR uses displays, input devices, tracking devices, and a computer. In dentistry, AR was initially used in education to provide an immersive experience while learning virtually. In prosthetic rehabilitation with dental implants, AR enabled the visualization of the digital images and preoperative planning data superimposed on the surgical field, which assisted accurate implant positioning and drilling on the correct spatial position. Implant placement accuracy significantly improved, and operation time was significantly reduced. However, specific software applications should be further upgraded to optimize the results. In aesthetic smile design, AR provides the patients with a preview of their makeover during their discussion appointment and saves the dentist time that was consumed by multiple photographs capturing and the mock-ups creation. Mobile applications are being developed to simplify the design procedure, enhance patient integration, and facilitate communication with laboratory partners.

Keywords: *Augmented Reality; Prosthodontics; Implantology; Dynamic Navigation; Smile Design*

Abbreviations

2D: Two Dimensional; 3D: Three Dimensional; AR: Augmented Reality; CBCT: Cone Beam Computerized Tomography; CAD: Computer-Aided Design; CAM: Computer-Aided Manufacture; MRI: Magnetic Resonance Imaging

Introduction

Prosthetic dentistry is one of the dental branches that has evolved remarkably over the last decades taking advantage of the digital innovations and technological advancements in diagnosis, treatment planning, computer-aided design/computer-aided manufacturing of prosthetic appliances, and delivery of advanced treatment.

Augmented reality (AR) is an enhanced version of virtual reality created using digital technology to superimpose virtual and real objects in a single realistic environment on an operator's view of the real world, hence creating a computer-generated working scenario to enhance the sensory perception by interacting with it [1]. AR technology consists of devices including displays that are either head-mounted, handheld, or spatial displays, input devices, tracking devices, and a computer. Recently, AR systems utilized contact lenses and virtual retina displays to show scanned images directly onto the viewer's eyes' retina. While tracking devices involved digital cameras and similar optical sensors, accelerometers, solid-state compasses, global positioning systems [GPS], and wireless sensors [2]. The superimposed virtual objects are usually obtained from 3-dimensional computed tomographic dental scans, MRI, angiography, or other 3-D data [3].

In dentistry, AR was initially used in education in contribution with haptic feedback that introduced the perception of force sensation. It was possible to have an immersive experience while learning in a virtual environment. AR enhanced education outcomes supported patient safety and objectively evaluated students, and gave them direct feedback [4]. The scope of indications of AR has expanded to incorporate radiology, orthodontic bracket positioning, prosthetics augmentation, management of dental phobia, endodontic surgery, and oral and maxillofacial surgery [2].

AR and prosthodontics

In prosthetic rehabilitation of missing, badly destructed, and aesthetically unaccepted teeth, most patients are particularly concerned about the results of the lengthy treatment procedures and their fears driven from their ignorance of the anticipated results that might not meet their expectations. The introduction of AR, which allows the dentist and the patient to inspect a superimposed digital visualization of the treatment outcome, would import patient satisfaction and trust to proceed with the costly treatment process. Thus, AR has the potential to simplify prosthetic treatment to meet patients' expectations. In addition to facilitating communication of the practitioner with the dental laboratory technician responsible for translating the operator's plans into realism. This article aims to provide an overview of the application of AR in the dental discipline of prosthodontics.

AR in implant-prosthetic rehabilitation

AR enabled the visualization of digital images and preoperative planning data to assist in accurately positioning of the dental implants and drilling on the correct spatial position. AR is especially significant regarding the oral and maxillofacial region, where the peculiar anatomical complexity of the region has always complicated the surgical position of dental implants [5]. Surgical navigation implicates knowing proper anatomical orientation and the prediction of implant position in bone before starting the incision. AR systems project the patient's data and pictures as retrieved from computed tomography, MRI, anatomic models, and intraoperative pictures directly on the surgical site. AR has been shown to improve dental implant positioning when a graphically superimposed suggested position is used on the patient during implant placement [3]. AR implant surgical navigation was presented using retinal imaging rather than monitor display to avoid looking away from the oral surgical field during the operation. Furthermore, AR systems were improved to act as an automatic information filter that selectively displays only the surgeons' most relevant information [1].

In prosthetic rehabilitation with dental implants, the focus of AR technology was to achieve a more visible surgical field during the operation, which was brought using specific glasses and an integrated screen. AR allowed the surgeon to visualize, in real-time, patient parameters, relevant x-rays, 3D reconstruction, or a navigation system screen [6].

Many studies have been done to illustrate the efficiency of AR in dental implant surgical planning. A study done by Lin., *et al.* used the stereoscopic visualization concept combined with head-mounted AR displays, revealed that implant placement accuracy, as measured by the deviation between the planned and the prepared positions of the implants, significantly improved by combined integration of the surgical template and AR technology [7].

Jiang., *et al.* attempted placing dental implants in edentulous mandibular models using 3D AR-guided implant navigation. The postoperative results showed better accuracy, higher efficiency, and shorter time for the 3D AR navigation than the traditional 2D image navigation method [8].

The accuracy of dynamic implant navigation using AR HoloLens was presented by Pellegrino., *et al*. The position of the implants was virtually planned. It contributed to a dynamic navigation system in addition to a computer-aided/image-guided procedure. The HoloLens enabled the visualization of 2D/3D data and permitted device-control via voice commands or simple gestures, which helped the practitioner to visualize the system data, information, targets, and positions by placing a virtual desktop near the patient's face without being forced to look away from the patient's mouth. The study appraised AR as a valuable tool in reducing operation time and accurate implant positioning, although it recommended that specific software applications be further upgraded to optimize the results [6].

In another study, AR navigation with accurate CBCT-patient registration for dental implant placement demonstrated acceptable implant accuracy, intraoperative time, and resolution of the hand-eye coordination problem [9].

AR and aesthetic smile design

In dentistry, smile reconstruction has been achieved using lengthy and detailed methodologies. A pre-visualization was achieved utilizing a conventional laboratory-made wax-up and intraoral mock-up, in the form of a two-dimensional smile design by overlapping idealized teeth forms onto a picture of the patient. Protocols were proposed using only a set of photographs and presentation software to offer a predictive view of the patient's future smile and to transfer treatment plan to the dental laboratory technician. Nevertheless, these protocols were hindered by the two-dimensional presentation and were only partially immersive for

the patients [10]. AR provides the patients with a preview of their aesthetic smile makeover at no obligation during their discussion appointment and saves the dentist time consumed by capturing multiple photographs or creating mock-ups.

In attempts to improve patient experience and patient-practitioner communication, recent technological evolutions were proposed. Mobile applications were suggested to ease the process of pre-visualization of the future patient smile by simply looking at the mobile camera; consequently, explaining complex treatment options was easier. Observing a virtual mirror helped the patient to decide whether to invest in the detailed, cost-intensive, and time-consuming planning of the cosmetic treatment or not. The remarkable before-and-after images and the possibility of viewing oneself with the new restorations in a virtual mirror is an enthusing experience for the patients. The app facilitates communication with the laboratory partners [10].

AVRspot [Smart Tek Solutions and Services LLC] proposed a face landmark recognition tool in a mobile app that identifies the patient's smile in an image and substitutes it on other smiles to determine the best fit. The app provides the users with tooth size and shape adjusting tools to match their desired smile [11].

Another contribution by Ivoclar Vivadent is the IvoSmile application available since 2019 and is compatible with Apple iPad, iPhone, and iOS 12 or higher. It provides patients with an image of their smile in a few minutes [12].

Touati., *et al.* examined the user-experience of smile design using facial recognition and two AR strategies. In his study, the IvoSmile app [IvoSmile®/Kapanu, Ivoclar-Vivadent] used the camera integrated into a tablet to recognize the patient's face. After determining virtual facial and oral landmarks, a second software proposed an artificial layer of smile suggestions that was superimposed on the patient's smile. The patient was given the full opportunity to explore possibilities of his smile reconstruction, and accordingly, AR technology and the mobile app integrated the patient into the decision-making process for reconstruction of the aesthetic zone [10] his process was further uplifted with a new tool called "CAD-link", which directly matched the final AR proposal with a digital impression to create a digital wax-up [13]. Merchand., *et al.* presented this novel digital workflow combining AR and CAD/CAM technologies in a case report to illustrate the opportunity of AR in daily dental practice. Using the 'CAD-link' workflow combined with the AR software and the CAD software, the maxillary anterior reconstructions were planned precisely according to the previously developed design proposal of the AR software approved by the patient. The CAD-link was used to design a wax-up mock, which was fabricated using CAM technology. After the patient approved the mock-up, it was used to prepare a silicone index to guide the minimally invasive planned preparation [14].

Future innovations

AR-based artificial intelligence contributes novel inputs in prosthodontics. Robotic systems, machine learning, and artificial intelligence can shape the future of dentistry through the ability to deal with and process massive data. Artificial intelligence is a branch of computer science concerned with building intelligent software or machines capable of running different errands that demand human intelligence. Artificial intelligence has been reported promising in maxillofacial surgery, robotic education, tooth preparation for crowns and bridges, testing tooth brushing, root canal treatment, plaque removal, orthodontics and jaw movements, material testing, tooth arrangement for complete dentures, image radiography, and robot assistance. Robotic assistance may also be help support the dental technician [3].

The dental robots are thought to be utilized sooner to manufacture removable partial dental replacement, complete dental replacement, and implant prosthesis. However, the innovation is expensive and requires attention to the techniques' inherent complexity and hardware.

Conclusion

AR presented novel innovations in dentistry and, prosthetic rehabilitation. The significant advantage of AR in prosthetic rehabilitation is accuracy, saving working time, better communication with the patient and the laboratory technician as it accomplishes the tasks with minimum human fatigue. AR reality showed significant success in dynamic implant navigation. It is a promising technology in smile design that allows pre-visualization of the treatment and active patient engagement in decision making. Nevertheless, still more advancements are required in the quality of image construction, flexibility of the software, and ease of integration in the daily dental office. ore evolution is required for three-dimensional conception, video analysis, functional movement evaluation, and prosthesis design. The cost of the systems is expensive, and few aspects

of understanding and conversions to clinical practice are challenging and require extensive research and development.

Conflict of Interest

The author declares the absence of any financial interest or any conflict of interest.

Bibliography

1. Kwon H-B, Park Y-S, Han J-S. Augmented reality in dentistry: a current perspective. Acta Odontol Scandinivica. 2018;76(7):497-503.

2. Rana K, Sharma B, Sarkar S, Choudhary SR. When virtuality merges with reality Application of virtual reality and augmented reality in dentistry - A literature review. SRM J Res Dent Sci. 2021;12:161-167.

3. Grischke J, Johannsmeier L, Eich L, Griga L, Haddadin S. Dentronics: Towards robotics and artificial intelligence in dentistry. Dent Mater. 2020;36(6):765-778.

4. Moussa R, Alghazaly A, Althagafi N, Eshky R, Borzangy S. Effectiveness of virtual reality and interactive simulators on dental education outcomes: Systematic review. Eur J Dent. 2021.

5. Farronato M, Maspero C, Lanteri V, et al. Current state of the art in the use of augmented reality in dentistry: A systematic review of the literature. BMC Oral Health. 2019;19(1):135-150.

6. Pellegrino G, Mangano C, Mangano R, Ferri A, Taraschi V, Marchetti C. Augmented reality for dental implantology: A pilot clinical report of two cases. BMC Oral Health. 2019;19(1):1-8.

7. Lin YK, Yau HT, Wang IC, Zheng C, Chung KH. A novel dental implant guided surgery based on integration of surgical template and augmented reality. Clin Implant Dent Relat Res. 2015;17(3):543-553.

8. Jiang W, Ma L, Zhang B, et al. Evaluation of the 3D augmented reality-guided intraoperative positioning of dental implants in edentulous mandibular models. Int J Oral Maxillofac Implants. 2018;33(6):1219-1228.

9. Ma L, Jiang W, Zhang B, et al. Augmented reality surgical navigation with accurate CBCT-patient registration for dental implant placement. Med Biol Eng Comput. 2019;57(1):47-57.

10. Touati R, Richert R, Millet C, Farges JC, Sailer I, Ducret M. Comparison of two innovative strategies using augmented reality for communication in aesthetic dentistry: A pilot study. J Healthc Eng. 2019;2019:7019046.

11. AVRspot (acquired by Smart Tek Solutions and Services LLC). Augmented reality smile application (2020).

12. Vivadent I. IvoSmile-app. 2019.

13. Touati R, Fehmer V, Ducret M, Sailer I, Marchand L. Augmented reality in aesthetic Dentistry: a Case Report. Curr Oral Heal Reports. 2021;8:23-28.

14. Marchand L, Touati R, Fehmer V, Ducret M, Sailer I. Latest advances in augmented reality technology and its integration into the digital workflow. Int J Comput Dent. 2020;23(4):397-408.

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